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***Retrospective Study***

**Fecal microbiota transplantation induced remission of infantile allergic colitis through microecology re-establishment**

Liu SX *et al.* FMT on infantile AC treatment

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**Author contribution:** Liu SX and Li YH contributed equally to this work; Shu SN and Huang ZH designed the research; Dai WK designed the follow-up plans and collected patients’ information with Li XS, Ruan ML, Zou B and Dong C after FMT; Qiu QZ, Liu YH and He JY performed bioinformatic analysis; Ruan ML and Zou B recorded patients’ and donors’ clinical data. Shu SN and Huang ZH conducted FMT.

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**Abstract**

***AIM***

To investigate the impacts of fecal microbiota transplantation (FMT) treatment on allergic colitis (AC) and gut microbiota (GM).

***METHODS***

We selected a total of 19 AC infants, who suffered from severe diarrhea/hematochezia, did not relieve completely after routine therapy, cannot adhere to the therapy and were free from organ congenital malformations and other contraindications for FMT. Qualified donor-derived stools were collected and injected to the AC infants *via* a rectal tube. Clinical outcomes and follow-up observations were noted. Stools were collected from 10 AC infants before and after FMT, and GM composition was assessed for infants and donors using 16S rDNA sequencing analysis.

***RESULTS***

After FMT treatment, AC symptoms in 17 infants were relieved within 2 d, and no relapse was observed in the next 15 mo. Clinical improvement was also detected in the other 2 AC infants who were lost to follow-up. During follow-up, 1 AC infant suffered from mild eczema and recovered shortly after hormone therapy. Based on the 16S rDNA analysis in 10 AC infants, most of them (*n =* 6) had greater GM diversity after FMT. In the result, Proteobacteria decreased (*n =* 6) and Firmicutes increased (*n =* 10) in post-FMT AC infants. Moreover, Firmicutes accounted for the greatest proportion of GM in the patients. At the genus level, *Bacteroides* (*n =* 6), *Escherichia* (*n =* 8), *Lactobacillus* (*n =* 4) were enriched in some AC infants after FMT treatment, but the relative abundances of *Clostridium* (*n =* 5), *Veillonella* (*n =* 7), *Streptococcus* (*n =* 6) and *Klebsiella* (*n =* 8) decreased dramatically.

***CONCLUSION***

FMT was a safe and effective method for treating pediatric patients with AC and restoring GM balance.

**Key words:** Pediatric; Infantile allergic colitis; Fecal microbiota transplantation; Gut microbiota; Immune reaction

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**Core tip:** This retrospective study explored the therapeutic effects and safety of fecal microbiota transplantation (FMT) treatment on 19 allergic colitis (AC) infants who were younger than 1-year-old. After FMT treatment, AC symptoms were relieved in the patients rapidly, and no patient relapsed within 15 mo. With gut microbiota (GM) analysis, 6/10 patients exhibited higher microbial diversity after FMT treatment. Moreover, decreased Proteobacteria and increased Firmicutes supplied the hints of GM re-establishment in the patients after FMT treatment. Therefore, this work showed the curative effects of FMT to the AC infants and its possible mechanism.

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**INTRODUCTION**

Allergic colitis (AC) is the common infantile rectal bleeding disorder which is caused by severe allergic reactions within the digestive system[[1](#_ENREF_1),[2](#_ENREF_2)]. AC is normally identified in infants younger than one year-of-age and its representative clinical features are hematochezia and diarrhea[[3](#_ENREF_3)]. Bloody purulent stools, abdominal pain, and vomiting are also used to diagnose AC[[3](#_ENREF_3)]. Various factors such as food allergens, aberrant immune system, and imbalanced gut microbiota (GM) are thought to contribute to AC[[4-6](#_ENREF_4)].

Conventional therapies for AC are reducing exposure to suspicious allergens and applying hypoallergenic milk powder[[7](#_ENREF_7)]. Maria Elisabetta Baldassarre *et al*’s[[8](#_ENREF_8)] group used probiotics to treat AC infants and their data showed that *Lactobacillus GG* may relieve symptoms of AC by altering GM composition[[8](#_ENREF_8)]. Fecal microbiota transplantation (FMT) can change gut micro-ecology more robustly in comparison to food or probiotics. Several reports suggested that FMT was therapeutically efficacious for treating diseases associated with GM dysbiosis, such as *Clostridium difficile* infection (CDI)[[9](#_ENREF_9),[10](#_ENREF_10)], inflammatory bowel disease (IBD)[[11](#_ENREF_11),[12](#_ENREF_12)] and irritable bowel syndrome (IBS)[[13](#_ENREF_13),[14](#_ENREF_14)]. However, to our knowledge, FMT has not been used to treat AC infants.

Thus, we assessed 19 AC infants with severe hematochezia and/or diarrhea, who hadn’t acquired complete remission after 2 wks’ routine therapy or the guardians can’t adhere to the routine therapy thoroughly. Our intention was to confirm the safety and efficacy of FMT on AC treatment, and detect the sustained GM changes after FMT.

**MATERIALS AND METHODS**

***Ethics***

This study was approved by Medical Ethics Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-C20140712). All subjects and donors gave signed informed consents. Principles of patients care and all experimental procedures followed the guidelines established by the Institutional Review Board in Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology.

***Patient selection***

AC was diagnosed based on the following clinical symptoms: (1) rectal bleeding with/without mucus and diarrhea; (2) exclusion of infectious colitis, anal ﬁssure, lymphoid nodular hyperplasia and uncommon conditions such as necrotizing enterocolitis, hirschsprung enterocolitis, IBD[[15](#_ENREF_15)] and IBS[[16](#_ENREF_16)]; (3) clinical remission after milk exclusion and recurrence after milk rechallenge[[3](#_ENREF_3),[17](#_ENREF_17)]; and (4) histological examination indicated that the intestinal mucosa exhibited chronic inflammation with eosinophils infiltration and the colonic lesions (Supplementary File 1). AC pediatric patients meeting the following criteria were selected as FMT candidates: (1) No complete remission after routine therapy, the patients can’t adhere to the therapy thoroughly or their parents had strong intentions to receive the treatment of FMT; (2) free from contraindications for FMT, such as intestinal obstructions, perforations and bleeding, severe immunodeficiency diseases; (3) colonoscopic inspection indicated no mucosal congestion, edema, multiple spot-like erosion, or lymphoid granular nodes (4 cases included in Figure 1); and (4) 19 AC patients were enrolled in the study between Sep 2015 and Dec 2015 (Table 1).

***Donor screening***

Patients’ mothers were considered to be donors of the highest priority, followed by fathers and healthy peers. Adult donors were screened as follows[[18-20](#_ENREF_18)]: (1) No infectious diseases history (*e.g.*, tuberculosis, hepatopathy and *etc*.); (2) no metabolic diseases history (*e.g.*, obesity, diabetes and *etc*.); (3) no gastrointestinal diseases (*e.g.*, diarrhea, constipation, IBD, IBS, colorectal polyps, gastrointestinal tumors and *etc*.); (4) no allergic diseases (*e.g.*, food allergy, eczema, allergic gastroenteritis and *etc*.); (5) no antibiotic exposure in the last 3 months; (6) no mental disorders or autoimmune diseases; and (7) no drug abuse history, amenorrhea (for mother donors), or psychological imbalance.

Candidate donors of the same age were selected with the following criteria[[18-20](#_ENREF_18)]: (1) preferred relatives with breast milk-fed and same gender; (2) no antibiotic treatment in the last 3 months; (3) no allergic disease (*e.g.*, food allergy, eczema, allergic gastroenteritis and *etc*.); (4) no gastrointestinal disease (*e.g.*, diarrhea, constipation, IBD, IBS, colorectal polyps, gastrointestinal tumors and *etc*.); (5) no metabolic disease history (*e.g.*, obesity, diabetes and *etc*.); and (6) no infectious disease history (*e.g.*, tuberculosis, hepatopathy, measles and *etc*.), normal health and development. Tests for serum biochemistry and stool were performed for donors to ensure subject safety (Table 2).

***FMT procedure***

The application of parenteral nutrition and probiotic were ceased as soon as FMT begins in the patients. No bowel preparation (cleanout or antibiotic pretreatment) was used prior to FMT, but pre-FMT clinical tests were performed as described in Table 3. Donor stool, collected 2 hours before FMT, was diluted and mixed with sterile saline (1mg of stool was diluted with 3ml of saline). Samples were filtered through sterile gauze and 30–50 ml fecal suspension was prepared for FMT. FMT was administered over 5–10 min *via* rectal tube into the left colon. The rectal tube was removed fifteen minutes after administration and the fecal suspension was retained in the recipients’ gut for 4–6 h. Multi-FMT was given for patients with severe symptoms (Table 1).

***Follow-up***

Clinical symptoms, stool frequency, symptom remission time and adverse events (*e.g.,* abdominal pain, gastroenterology infection, constipation, fever, allergic disease and *etc*.) were recorded at the end of FMT (Table 1). Follow-up was conducted at ≥ 15 mo after FMT, except for 2 cases with 0.3 and 0.5 mo follow-up (AC17 and AC19), to evaluate FMT efficacy and safety (Table 1). The remission of AC was defined as the cease of rectal bleeding and decreased stool frequency (no more than 2 times/d) in the patients. The primary endpoint was the improved AC symptoms and sustained clinical remission at 12 mo. Secondary endpoint was the safety of FMT which was implied by the occurrence of adverse events.

***Microbiota analysis and statistics***

Fecal microbiota was analyzed for 10 patients before FMT and during follow-ups. Donor feces were also assayed for GM. Microbial DNA was extracted using a PowerSoil DNA Isolation Kit (Mo Bio Laboratories, Carlsbad, CA) according to the manufacturer’s protocol and the hyper-variable V3-V4 region was amplified by 338F (5'-ACTCCTACGGGAGGCAGCA-3') and 806R (5'-GGACTACHVGGGTWTCTAAT-3') primers. Library construction and sequencing was conducted on an Illumina MiSeq platform (Illumina, San Diego, United States). Data filtration and analysis was performed as a prior report with the RDP database as an annotation reference[[21](#_ENREF_21)]. A Wilcoxon signed-rank test was used to compare samples of one patient, which were collected at different time-points, and a Wilcoxon rank-sum test was used to compare donor and patient samples. Graphs were produced with R package (version 3.2.3).

**RESULTS**

***Recipient characteristics***

FMT recipients aged from 4 to 11 mo (11 boys and 8 girls) and had hematochezia or severe diarrhea. Disease duration of AC patients was 0.5-3 mo for 16 cases and 3-6 mo for 3 cases (Table 1). Formula was replaced with hypoallergenic milk powder in all patients’ dietary, and 11 of them were exposed to probiotic before FMT treatment (Table 1). The colonoscopic inspection of 4 AC infants was included in Figure 1.

***FMT safety and efficacy***

Infants experienced low-quality sleep and weight loss since the onset of AC, but no one was malnourished. And they had significant clinical remission within 2 d after the first FMT treatment (Table 1). After FMT, hematochezia or diarrhea rapidly improved in AC patients, and decreased defecation frequency with improved stool consistency was also observed (Table 1). Within more than 15 mo follow-up, the symptoms of AC had not relapsed except two patients who were lost to follow-up (AC17 and AC19). Only one patient suffered from eczema, which appeared 2 mo after FMT and was resolved with hormone therapy. Beyond this, no other adverse event was recorded during FMT or the follow-up.

***FMT treatment associated microbiota changes***

Figures 2 and 3 depict microbiota changes of 10 patients before and after FMT compared to donors. Microbiota diversity increased dramatically in five patients while it decreased in 3 patients after FMT (Figure 2). When sampled one or two months after FMT, microbiota of 6 patients was more similar to donors’ microflora by comparison with pre-FMT samples (Figure 3).

After FMT treatment, Firmicutes accounted for the greatest proportion of GM in the AC infants, followed by Bacteroidetes and Proteobacteria. Proteobacteria decreased dramatically to < 10% for most patients except 4 patients (Supplementary File 2). Whilst, Firmicutes increased in all patients (Supplementary File 2).

The relative abundance of *Escherichia* significantly increased in 8 AC infants (Supplementary File 3). *Bacteroides* increased in five AC infants including 3 who had no *Bacteroides* pre-FMT (Supplementary File 3). For four patients, *Lactobacillus* was enriched after FMT, but for 3 subjects, it was absent even after FMT. Possible pathogens including *Clostridium* and *Klebsiella* generally decreased after FMT. *Clostridium* and *Klebsiella* decreased in 5 and 8 AC infants respectively (Supplementary File 3)*.* The relative abundance of *Streptococcus* was lowered in 6 patients. Whilst, *Veillonella* was found decreased in 7 patients and its relative abundance was no more than 8% after FMT. *Bifidobacterium* kept decreased in 7 AC infants after FMT, and increased in 2 cases.

**DISCUSSION**

We chiefly considered curative effects of FMT therapy in 19 AC infants and microbiota changes during treatment. Stools from both infant and adult donors suggested the same efficacy, and it was noted that all subjects had relieved symptoms of hematochezia and/or diarrhea in 2 d after the first FMT treatment. Due to the longer illness time or sever clinical symptoms, 15 patients experienced multi-FMT for the sustained clinical remission. And the multiple FMT in these patients gave us the idea that artificial modified microbiota for the specified patient might elevate the efficiency of FMT and attenuate transplantation times in the future. After being discharged from hospital, the patients were advised to take hypoallergenic milk powder instead of formula, and most patients had no relapse of colitis with more than 15-month’s follow-up. The recurrence of eczema in one infant might be caused by the inflammatory reactions which were triggered by discontinuous intake of hypoallergenic milk powder.

Fecal microbiota was analyzed in 10 patients and their donors. We noted that the microbiota diversity increased in 6 patients after FMT. For 3 other subjects, GM diversity decreased after an initial increase while all the patients demonstrated clinical improvement. Individual-specific GM changes suggested the effect of donor’s GM complexity and patient’s gut micro-ecology imbalance. Alexander Khoruts *et al*[[10](#_ENREF_10)] also suggested that bacteria can be eliminated due to nutrient competition, antimicrobial peptide suppression and immune-mediated colonization resistance during GM re-establishment.

Proteobacteria, which contain opportunistic pathogens[[22](#_ENREF_22)], decreased in 6 AC infants, and its relative abundance was less than 10% after FMT. In contrast, Firmicutes increased in all AC infants. Previous work implied that Firmicutes reduced in patients with Cohn’s disease (CD)[[23](#_ENREF_23)], and the proportion of Firmicutes was negatively associated with gastroenterology inflammation[[24](#_ENREF_24)].

After FMT, the relative abundances of *Bacteroides* and *Lactobacillus* increased. Prior reports showed that species in *Bacteroides* could secrete polysaccharide A which promoted the number of Treg (T regulatory cells) cells[[25](#_ENREF_25),[26](#_ENREF_26)]. IL-10 (interleukin-10) produced by Treg cell also eliminated inflammation reactions and protected against infectious pathogens[[25](#_ENREF_25),[26](#_ENREF_26)]. *Lactobacillus* can secrete lactic acid, increase the proportion of Treg cells and relieve symptoms of AC[[8](#_ENREF_8),[27](#_ENREF_27)]. Generally, the relative abundance of opportunistic pathogens decreased, including *Veillonella*, *Streptococcus*, *Clostridium* and *Klebsiella*. Prior reports suggested that the combination of *Veillonella* and *Streptococcus* had been found in various GM systems, through augmenting IL-8 (interleukin-8), IL-6 (interleukin-6) and TNF-ɑ (tumor necrosis factor ɑ) responses, which were associated with inflammation reactions[[28](#_ENREF_28)]. *Clostridium* can cause diarrhea *via* enterotoxin secretion, and *Klebsiella* positively associated with MIF (macrophage migration-inhibitory factor) and affected host immunity[[29](#_ENREF_29)]. However, GM imbalance and post-FMT improvement needs more analysis to understand the mechanisms underlying AC improvements.

This study pioneered the application of FMT in AC treatment and provided important reference to understand microbiota changes before and after FMT. Although the results favor the application of FMT on AC treatment, it is still important to clarify whether AC symptoms can be improved with larger sample size in our future studies. Also, we will explore the microbiota changes at the gene or functional level before and after FMT, to further the understanding of GM imbalance and re-configuration during FMT treatment of infantile AC.

**ARTICLE HIGHLIGHTS**

***Research background***

Allergic colitis (AC), which was characterized as hematochezia and severe diarrhea, is caused by an intense allergic reaction of the digestive system. Currently, first-line therapies for AC patients are reducing exposure to suspicious allergens and applying hypoallergenic milk powder. However, some pediatric patients could not relieve from AC symptoms completely with routine treatment, and long-term illness cause adverse impacts on nutrition absorption and physical development in the children.

***Research motivation***

Previous researches indicated that gut microbiota (GM) was closely related with digestive system, neural system and immune system in human. Meanwhile, the positive effects of fecal microbiota transplantation (FMT) have been confirmed in various gastroenterology diseases, including *Clostridium difficile* infection (CDI), inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS). However, FMT had not been applied to treat AC infants before. And this research could provide important references for the treatment and research of infantile AC with FMT therapy.

***Research objectives***

The research aimed to detect the safety and efficiency of FMT treatment on AC, and compared GM composition before and after FMT treatment in the patients.

***Research methods***

The procedures of FMT, including AC patients and donors selection, were conducted according to the guidelines established by the Institutional Review Board in Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology. Wilcoxon tests were adopted in the research.

***Research results***

In this study, the safety and efficacy of FMT treatment were investigated in 19 AC infants with GM analysis. The results indicated that the AC symptoms, which including rectal bleeding, diarrhea and hematochezia, were relieved rapidly by FMT treatment. During 15 mo follow-up, no relapse was recorded except eczema happened in one patient. After FMT treatment, the elevation of microbial diversity was detected in 6/10 patients. Meanwhile, the relative abundances of Proteobacteria and Firmicutes were decreased (6/10) and increased (10/10) respectively in the AC infants.

***Research conclusions***

This study documents the positive effect of FMT treatment on infantile AC remission, suggesting the potential of FMT in gastrointestinal allergic diseases. Individual-specific GM re-configuration also extended our understanding of FMT efficacy and associated mechanisms.

***Research perspectives***

Despite the aspiring results of FMT on pediatric AC, verified improvements with larger cohorts and longer follow-up are necessary. In parallel, GM analysis should be performed before and after FMT, to unravel keystone microbial components in the specific disease.

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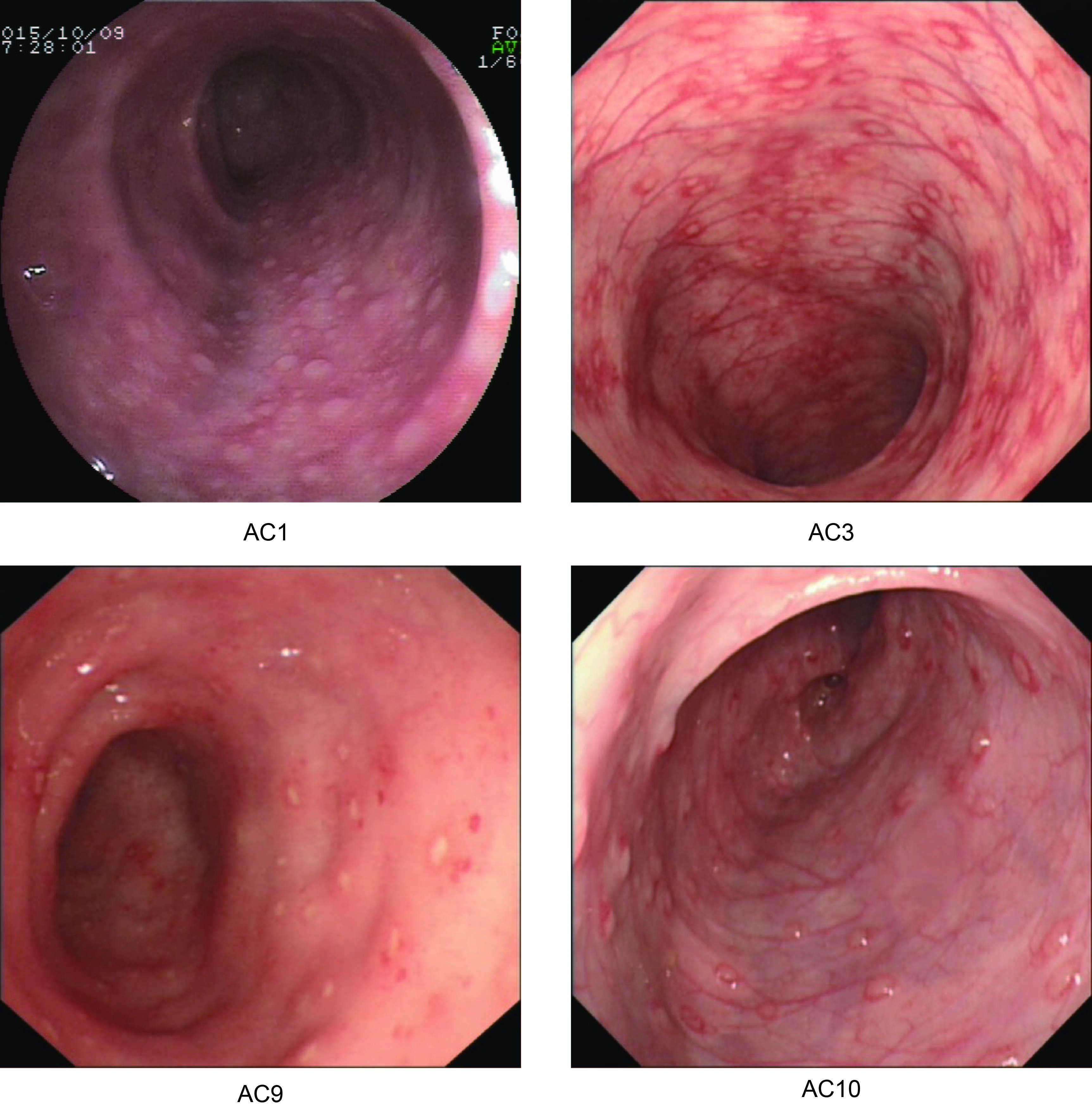
Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): C, C

Grade D (Fair): 0

Grade E (Poor): 0

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**Figure 1 Colonoscopic inspection of 4 allergic colitis patients prior to fecal microbiota transplantation.** Colonoscopic images of patients (AC1, AC3, AC9 and AC10) were conducted prior to FMT. **AC:** Allergic colitis; **FMT:** Fecal microbiota transplantation.

**E:\微健康-医学研究\05.微健康医学研究项目\01.在线项目\1.FMT治疗过敏性肠炎项目-武汉同济医院\3.文章投稿\第三次投稿-World Journal of Gastroenterology\修改内容-20170928\alpha.ac(2)-01.tif**

**Figure 2 Shannon rarefaction curves of gut microbiota from 10 allergic colitis infants and their donors.** Each image represents one AC infant, and each curve represents one fecal sample from a patient or the corresponding donor. Sample ID has 3 parts: ‘R’ or ‘D’ to indicate AC infants or donors, ’pre’ or ‘post’ represent the stools collected before or after FMT, and fecal collection date. Microbiota diversity in six patients (AC1, AC4, AC5, AC7, AC8 and AC9) increased after FMT treatment. AC: Allergic colitis; FMT: Fecal microbiota transplantation.

**E:\微健康-医学研究\05.微健康医学研究项目\01.在线项目\1.FMT治疗过敏性肠炎项目-武汉同济医院\3.文章投稿\第三次投稿-World Journal of Gastroenterology\修改内容-20170928\Beta.10(2)-01.tif**

**Figure 3 Microbiota similarity between allergic colitis infants and their donors.** Values in red indicate low microbiota similarity between 2 samples. Blue represents high microbiota similarity. The microbiota compositions of patients (AC1, AC2, AC4, AC5, AC6, AC7, AC8 and AC10) were more similar to their donors’ composition after FMT treatment. One patient (AC9) had more and then less microbiota similarity and AC3 did not change in this regard. AC: Allergic colitis.

**Table 1 Clinical information for 19 allergic colitis infants**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Gender | Age (mo) | Symptoms | Duration of disease (mo) | Treatments before FMT | Donor source | FMT times | Symptom remission after first FMT (d) | Stool frequency before and after FMT  (times/d) | Follow up (mo) | Availability of gut microbiota data |
| AC1 | Female | 7 | Diarrhea, hematochezia sometimes; anemia; hypohepatia | > 3 | Applying amino acid formula and probiotics (*C. butyricum*) | Mother | 2 | 1 | 3-4, 1 | 19 | Yes |
| AC2 | Male | 10 | Hematochezia | > 0.5 | Applying amino acid formula and probiotics (*Bifidobacteria*) | Healthy infants with 10 mo old | 2 | 1 | 2-3, 1 | 18 | Yes |
| AC3 | Female | 11 | Hematochezia | > 3 | Applying amino acid formula and probiotics (*S. boulardii*) | Healthy infants with 8 mo old | 3 | 1 | 5-6, 2 | 19 | Yes |
| AC4 | Male | 9 | Hematochezia | > 3 | Applying amino acid formula and probiotics (*S. boulardii*) | Mother's cousin sister | 3 | 1 | 6-7, 1-2 | 18 | Yes |
| AC5 | Male | 5 | Diarrhea and hematochezia sometimes | > 3 | Applying amino acid formula | Healthy infants with 8 mo old | 3 | 1 | 3-4, 2 | 19 | Yes |
| AC6 | Male | 5 | Hematochezia | > 3 | Applying amino acid formula and probiotics (*C. butyricum*) | Mother | 1 | 2 | 5-6, 1 | 18 | Yes |
| AC7 | Male | 4 | Hematochezia and cough sometimes | > 2 | Applying amino acid formula and nebulization | Mother | 2 | 2 | 4-7, 1 | 15 | Yes |
| AC8 | Female | 3 | Diarrhea and mucoid feces happened sometimes | > 2 | Applying amino acid formula | Mother | 2 | 1 | 3-4, 1-2 | 19 | Yes |
| AC9 | Male | 11 | Interval hematochezia | > 6 | Appling amino acid formula and probiotics *(S.boulardii*) | Mother | 2 | 1 | 3-4, 2 | 23 | Yes |
| AC10 | Female | 3 | Hematochezia | > 1.5 | Applying amino acid formula | Healthy infants with 10 mo old | 4 | 2 | 5-6, 1 | 21 | Yes |
| AC11 | Male | 7 | Diarrhea | > 2 | Applying amino acid formula, probiotics (*Bifidobacteria*), Smecta and Oral Rehydration Salts (ORS) | Healthy infants with 10 mo old | 5 | 1 | 5-6, 1 | 23 | No |
| AC12 | Female | 10 | Diarrhea and hematochezia sometimes | > 1 | Applying amino acid formula and probiotics (*Bifidobacteria*) | Mother | 3 | 1 | 5-6, 1-2 | 22 | No |
| AC13 | Male | 5 | Hematochezia and diahhrea sometimes | > 3 | Applying amino acid formula | Mother | 1 | 1 | 3-4, 1 | 15 | No |
| AC14 | Female | 5 | Hematochezia and then peptone shaped feces happened | > 1 | Applying amino acid formula and probiotics (*Bifidobacteria*) | Mother | 1 | 1 | 7-8, 2 | 15 | No |
| AC15 | Male | 7 | Diarrhea | > 2 | Applying amino acid formula, ORS, and probiotics (*C. butyricum*) | Mother | 5 | 1 | 5-6, 1 | 21 | No |
| AC16 | Female | 5 | Interval hematochezia | > 2 | Appling amino acid formula | Healthy infants with 8 mo old | 2 | 1 | 4-5, 1 | 21 | No |
| AC17 | Male | 7 | Diarrhea and hematochezia happened sometimes | > 3 | Applying amino acid formula, probiotics (*Bifidobacteria* and *C. butyricum*) | Healthy infants with 11 mo old | 1 | 2 | 3-4, 1-2 | 0.5 | No |
| AC18 | Female | 8 | Diarrhea and cough sometimes | > 4 | Applying amino acid formula and nebulization | Healthy infants with 8 mo old | 2 | 1 | 3-4, 2 | 17 | No |
| AC19 | Male | 5 | Interval diarrhea | > 4 | Applying amino acid formula | Mother | 4 | 1 | 3-4, 1 | 0.3 | No |

AC: Allergic colitis; FMT: Fecal microbiota transplantation.

**Table 2 Laboratory testing on donors**

|  |
| --- |
| **Blood testing**  Blood transfusion examinations: Quantifications of hepatitis B surface antigen, hepatitis B surface antibody, hepatitis B E antigen, hepatitis B E antibody, hepatitis B core IgM antibody, hepatitis C antibody, human immunodeficiency virus antibody and treponema pallidum antibody.  TORCH examinations: Detections on toxoplasmosis IgG, toxoplasmosis IgM, rubella virus IgG, rubella virus IgM, cytomegalovirus IgG, cytomegalovirus IgM, herpes simplex virus 1/2 IgG and herpes simplex virus 1/2 IgM.  Detection on Parvovirus B19.  Epstein-barr virus examinations: Detections on Epstein-barr virus capsid antigen IgA, Epstein-barr virus capsid antigen IgG, Epstein-barr virus capsid antigen IgM, Epstein-barr virus early antigen IgG, Epstein-barr virus nuclear antigen IgG.  Blood type examination.  Lymphocyte subpopulation examination.  Food allergen examination (sIgE).  Hepatic and renal function examinations: Glutamic-pyruvic transaminase, glutamic oxalacetic transaminase, total protein, albumin, globulin, prealbumin, total bilirubin, direct bilirubin, indirect bilirubin, alkaline phosphatase, gamma glutamyltranspeptidase, total cholesterol , triglycerides, high-density lipoprotein, low density lipoprotein, apolipoprotein A1, apolipoprotein B, lactic dehydrogenase, calcium, corrected calcium, phosphorus, magnesium, urea, creatinine, trioxypurine, bicarbonate radical, total bile acid, 5–nucleotidase, α-L-Fucosidase, cholinesterase, cystatin C, lipase andamylopsin.  Mycobacterium tuberculosis antibody examination (or the enzyme-linked immuno-spot assay test for tuberculosis).  Immune system examinations: Quantifications of immune globulin A, immune globulin G, immune globulin M, alexin C3 and alexin C4.  Detection on hepatitis A-IgM.  Qualifications of C-reaction protein, erythrocyte sedimentation rate. |
| **Stool testing**  Fecal routine examinations: Detections on fecal colors, character, red blood cells, white blood cells, occult blood, parasite eggs, protozoon, fat ball, rotavirus antigen and fungus.  Bacterial culture tests: Detections on *Vibrio cholera*, *Salmonella*, *Shigella*, *Aeromonas*, *Plesiomonas*, and Pathogenic *Escherichia coli.* |
| **Other testing**  Chest X-ray.  Urea[C13] Capsule Breath Test.  Abdominal ultrasound scan.  [Electrocardiography](http://www.so.com/link?url=http%3A%2F%2Fdict.youdao.com%2Fsearch%3Fq%3Delectrocardiography%26keyfrom%3Dhao360&q=%E5%BF%83%E7%94%B5%E5%9B%BE%E6%A3%80%E6%9F%A5%E8%8B%B1%E6%96%87&ts=1488703835&t=39f0b40d936895f9e95fd9e6823cb06) examination. |

**Table 3 Laboratory testing of the patients before fecal microbiota transplantation**

|  |
| --- |
| **Blood testing**  Hepatic and renal function examinations: Glutamic-pyruvic transaminas, glutamic oxalacetic transaminase, total protein, albumin, globulin, prealbumin, total bilirubin, direct bilirubin, indirect bilirubin, alkaline phosphatase, gamma glutamyltranspeptidase, total cholesterol, triglycerides, high-density lipoprotein, low density lipoprotein, apolipoprotein A1, apolipoprotein B, lactic dehydrogenase, calcium, Correction of calcium, phosphorus, magnesium, urea, creatinine, trioxypurine, bicarbonate radical, total bile acid, 5–nucleotidase, α-L-Fucosidase, cholinesterase, cystatin C, lipase and amylopsin.  Food allergen examination (sIgE).  Lymphocyte subpopulation examination.  Detection on hepatitis A-IgM.  Blood transfusion examinations: Quantifications of hepatitis B surface antigen, hepatitis B surface antibody, hepatitis B E antigen, hepatitis B E antibody, hepatitis B core IgM antibody, hepatitis C antibody, human immunodeficiency virus antibody and treponema pallidum antibody.  TORCH examinations: Detections on toxoplasmosis IgG, toxoplasmosis IgM, rubella virus IgG, rubella virus IgM, cytomegalovirus IgG, cytomegalovirus IgM, herpes simplex virus 1/2 IgG and herpes simplex virus 1/2 IgM.  Detection on Parvovirus B19.  Blood coagulation examinations: Detections on prothrombin time, prothrombin activity, international normalized ratio, fibrinogen, activated partial thromboplastin time, thrombin time and d-dimer.  Blood type examination.  Mycobacterium tuberculosis antibody examination (or the enzyme-linked immuno-spot assay test for tuberculosis). |
| **Stool testing**  Fecal routine examinations: Detections on fecal colors, character, red blood cells, white blood cells, occult blood, parasite eggs, protozoon, fat ball, rotavirus antigen and fungus.  Bacterial culture tests: Detections on *Vibrio cholera*, *Salmonella*, *Shigella*, *Aeromonas*, *Plesiomonas*, and Pathogenic *Escherichia coli.* |
| **Other testing**  Enteroscopy examination.  Abdominal ultrasound scan (intestinal adhesion).  Electrocardiography examination. |